Corrections to **Background of the Invention**

incorporated **non synchronous** high speed alternators **with permanent magnets** [with]**to** the compressor/turbine rotor spool per initiating patent 6,314,717 offering reduced cost and simplicity. The Adkin patent 3,187,180 first implemented [the high speed alternator] a **generator rotor** [in] integration with **a single spool compressor turbine rotor into** a gas turbine engine removing the need for gearbox complexity and allowing for the first time frequency control independent of RPM engine speed; but power electronics remained costly and technology elusive to change high frequency and voltage to 60HZ@ 110 or 220 volts as an example. The 6,314,717 patent further introduced a low cost, low emissions single spool gas turbine with affordable available technology and power electronics yielding the first low cost electrical power generation system. Exclusively, to date small gas turbines <500 HP (not microturbines) have been used in auxiliary power units (APU) with constant speed generators or air cycle machines all incorporating gearboxes and used as ground base gen-sets or in aircraft. The prior microturbine applications are toward maximum power levels in stationary electrical power needs with a total system cost too high for vehicular applications as well as specific start/shutdown cycle to maximize heat exchanger mechanical stress/life. The total system

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capability of 0 to 60mph in <15 seconds minimum, have been requirements per Ford during the late 70's development program with the Garrett engine company. During these earlier tests, a 20% fuel economy improvement had been attained but the [accelaeration] **acceleration** tests were marginal. Although a good high effective recuperator > 90% has been experienced in a microturbine to yield good fuel economy (>29% cycle efficiency and better than conventional piston engine) durability is an issue. Also, during reduced power engine requirements, off loading from a high power levels using a current microturbine, the combustor flame stability will be an issue because of the initial stored heat energy in the recuperator device. The rotor system, with related rotor dynamics and or blade frequency could be of issue at reduced speed if not designed properly. The fuel control system may become complex and emissions be an issue during the engine transient operation using the current microturbines. In prior art the microturbine had controlled the engine power with fuel supply maintaining the engine at a constant or small range of engine speed and simultaneously varying the fuel flow

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incorporating (2) turbine/compressor rotor spool modules judiciously configured and housed. The #2 **rotor** spool, of the (2) **rotor** spools, incorporates bearings for rotatability, a turbine with blades attached to a hub, a compressor with blades attached to a hub, and an integral alternator rotor all positioned in the #2 [spool] housing. The #2 **rotor** spool develops rotational power to drive the integrated compressor and electrical alternator system thru the turbine wheel energy extraction of hot gas energy exiting the combustor. Within this #2 housing is an electrical stator co-axially positioned about the alternator rotor where relative rotational motion generates electricity. Also [include] **included** in this #2 housing are: an electrical stator oil cooling sleeve, bearing supports, output electrical power leads , output electric terminal block, air start nozzles within the compressor shroud area, a #2 compressor inlet duct to accept air from the #1 compressor **exit**. Attached to the #2 [spool] housing aft end of the compressor housing section is the diffuser and communicates with the combustor entrance and also attached is the #2 turbine nozzle and communicates with the combustor exit with a multi-piece seal plate between the compressor/diffuser and turbine nozzle to control compressor cooling air flow to the turbine hub. As an assembly this becomes the #2 **spool housing** module. The #2 [rotor] spool **module** [assembly] which is insertable as a system into the #2 housing, incorporates an aft bearing**-seal** [support] **housing** [and bearing] between the alternator rotor and **#2** compressor **rotor** and has **OD** oil seals axially displaced about the common cylindrical gap between the **#2** housing

ID and the **aft bearing-seal housing** [support] OD to supply oil to the bearing and act in partial **as** an oil squeeze film damper area.

The #1 spool housing module as a turbo charger has a compressed air exit that communicates with the #2 compressor inlet and is positioned in the #1 [spool] housing. The #1 **rotor** spool has bearings for rotation, a turbine **rotor** with blades attached to a turbine hub and a compressor **rotor** with blades attached to a compressor hub and as an assembly is housed within the #1 housing **communicates with the** [integral] compressor housing. Bearings are mounted in **the** related **#1** housing and have oil squeeze film dampers. Also, a compressor diffuser and turbine nozzle [is]**are** attached to the #1 [spool] housing aft end to create the #1 **spool housing** module. This #1 spool housing module is a turbo charger and the #2 spool housing module is the electrical power generating module and both connect to the combustor housing. A combustor is within the combustor housing where fuel is supplied to develop heat energy and drives the #1 and #2 turbine rotors of the related spools. The combustor gas **heat energy** is directed first to the #2 turbine thru the #2 turbine nozzle, **and** exiting this #2 turbine rotor the **energy** gas is ducted to the #1 turbine [via] **and thru** a #1turbine nozzle. The #1 [spool] housing retains the #1 **rotor** spindle [assembly] **sleeve**. The #1 **rotor** spindle [assembly] **sleeve** retains the bearings **and shaft seal** [and] **with** the #**1 rotor spool** and **is** axially positioned **and retained** within the #1[spool] housing from one end by a **rotor** retainer device.

The #1 [spool] housing receives the #1 **spool module** [spindle assembly] as a package **(#1 rotor spool, shaft bearings, seals, rotor spindle sleeve, and rotor retainer device)** and has a common circumferential radial space for oil supply to the

bearing<u>s</u> and the squeeze film damper rotor dynamic control area. Bearings have oil squeeze film damper on the cylindrical outside diameters of the bearings. Oil is supplied to the bearings and simultaneously thru the housing common dynamic clearances with seals. The #1 spool **<u>housing</u>** module system develops compressed air thru rotating blades, receives air from ambient supply and is driven by the #1 turbine from the hot gases exiting the #2 turbine discharge. A multi-piece seal between the compressor and turbine minimizes compressor leakage to the turbine disk.

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An object of the present invention is to provide an electrical power generating system having two rotor spools, a turbo charger, and alternator rotor that will overcome the shortcomings of the prior art devices and fully utilize the hybrid microturbine features (variable speeds for off design power **<u>and increased cycle pressure ratio</u>**).

Another object is to provide a electric power generating system with two rotor spools one as a turbo charger and the other spool incorporates an alternator to create electrical energy thru the use of a gas turbine engine. This will yield a compact, low weight, low emission, reduced cost, multi-fuel use, [vibraton] **<u>vibration</u>** free,high durability and black start capable hybrid microturbine. Also will remove the need for a recuperator/regenerator, decreasing the initial cost and increasing durability.

Another object is [the] **<u>to</u>** provide an electric power generating system

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Another object is to provide [a]**an** electric power generating system, having two rotor spools, one acting as a turbo charger and the #2 **rotor** spool having an integrated alternator to generate electricity, have rotor spool subassembly shaft seals and related bearing mounts have a common dampened housing yielding less shaft to seal excursions - minimizing related compressor air seal flow leakage.

Another object of this hybrid microturbine invention is to provide a electric power generating system, having two rotor spools, one acting as a turbo charger and the 2nd **rotor** spool having an integrated alternator to generate electricity is to reduce the turbine power necessary to drive the compressor allowing more available to drive the related alternator, thus improve fuel economy. A preferred embodiment could incorporate a moveable plate or vanes within a divergent

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system, having two rotor spools, one as a turbocharger and a 2nd rotor spool incorporating an alternator to generate electricity is to incorporate a retention device for the 1st spool[/spindle]**module** assembly to the #1housing thru a single point/area and be used for axial positioning of the **#1** rotor **spool** without shims, accept the related operational rotor thrust load and yet allow the **1st** rotor spool [– housing] relative radial dynamic movement.

Another object is to provide a electric power generating system, having (2) [Rotor/]**rotor** spools, one as a turbocharger and the 2nd rotor spool incorporating an alternator to generate electricity and incorporate a cooling means to the turbine

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Corrections to **BRIEF DESCRIPTION OF THE DRAWINGS**

Various other objects, features and attendant advantages of the present invention will become fully appreciated as the same becomes better understood when considered in conjunction with the accompanying drawings, in which like reference characters designate the same or similar parts throughout the several views, and (wherin) **wherein**:

Figure 1 is an [orthoganol] **orthogonal** -exploded- [pictora] **pictorial** drawing of the present invention.

Figure 2 is a 2 dimensional-exploded-[pictoral] **pictorial** drawing of the present invention.

Figure 3 is a half cross-sectional view 1st spool [rotor nodule and] housing [assembly]**module with case attachment** of the present invention.

Figure 4 is a cross-sectional view of the 2nd [spool rotor] **spool housing** module [and the housing] of the present invention **with case attachment**.

Figure 5 is a cross-sectional assembly view D figure 4 of the 2nd rotor-aft-bearing-seal housing of the present invention.

Figure 6 is a cross-sectional view E Figure 3, [and] partial 1st spool [front bearing] housing **module** of the present invention.

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Figure [19] **<u>19A</u>** is a partial cross sectional assembly view D of figure 4, 2nd spool aft bearing housing of the present invention **<u>with bearing end sealing.</u>**

<u>Figure 19B is a partial cross sectional assembly of the 1st spool aft bearing seal housing with bearing end sealing.</u>

Corrections to **DESCRIPTION OF THE PREFERRED EMBODIMENT**

Turning now descriptively to the drawings, in which similar reference characters [do note] **<u>denote</u>** similar elements throughout the several views, the attached figures illustrate a hybrid microturbine electric power generating system, having two rotor spools, one as a turbo charger, the 2nd **<u>rotor</u>** spool with an integral alternator all of which are housed electrical stator coaxially positioned about this rotor to create electrical power.

The 2nd rotor spool assembly and electrical stator assembly with cooling sleeve and electrical power out leads are retained in the #2 housing along with the 2nd compressor diffuser and 2nd turbine nozzle. The #1 spool module communicates with the #2 compressor inlet and as a turbo charger creates compressed air / working fluid and is positioned in the #1 [spool] housing with a compressor diffuser and turbine nozzle. The combustor housing [retains] **<u>attaches to</u>** the #1 and #2 spool housing modules and combustor where fuel is supplied to develop

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[spool] housing is part of the turbo-charger stage and retains the 1st [rotor/]spool module assembly, communicate with the combustor housing accepting hot gas energy exiting the 2nd turbine rotor[:]**,** begins the Brayton cycle with the air intake to the 1st spool rotor/compressor and [an] **supplies** compressed air flow [discharge] to the 2nd spool rotor/compressor inlet. A **thrust** bearing is incorporated into the 1st **rotor** spool**, rotor spindle sleeve** and thru a common **rotor** retainer **device,** is attached to the #1 housing for axial positioning and related rotor thrust loads. The #1 housing receives the 1st rotor spool assembly as a dynamically balanced module and has a relative fluid dynamic gap between the said spool assembly and the static **#1** housing to assist in the rotor dynamic stability.

Oil is supplied to the bearings and simultaneously thru the housing oil squeeze film radial clearances having seals. The 1st spool module develops, within the #1 housing, compressed air in this first stage from rotating blades driven by the 1st rotor/spool turbine using energy from the hot gases exiting the 2nd turbine rotor and also incorporates a multi-piece seal between the compressor and turbine rotors to separate the air and gas flows. The combustor housing retains the combustor for the development of fueled hot energy, **attaches to** the #1 spool[/rotor] housing module **and** the #2 [rotor/]spool housing module. The hot gas energy after the #2 turbine rotor is ducted to the #1 turbine nozzle where it is accelerated and directed to the 1st turbine wheel having blades to drive the 1st

thrust load. The #2 [spool] housing incorporates: and electrical output stator with a cooling means, output electrical power leads and output electric terminal block, an air start housing and the 2nd spool [assembly] module the latter of which compressor intake accepts compressed air from the 1st spool compressor discharge and communicates thecombustor housing. There are associated controlled case radial static clearances between the 2nd spool module assembly and the #2 housing and also at the bearing outside diameters with oil squeeze film dampers for improved rotor stability.

The alternator stator has a cooling sleeve attached to the outside diameter and insertable into the #2 housing and uses an oil media. The electrical power output assembly incorporates sealed metal leads within an electrical insulating block to allow external power lead attachments and attached to the #2 housing/engine case such to prevent oil leakage. Depending on the electrical phase requirements, the lead quantity could be 1,3, 6 or more.

The #1 [spool] housing 20 is part of the turbo-charger stage, retains the 1st

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[rotor/]spool [nodule] **module** assembly 40 communicates with the combustor housing 60 accepting hot gas energy 84 downstream of the 2^{nd} spool/rotor turbine122B. The Brayton Cycle begins with the air intake feature 24 of the #1 housing 20 and air flows thru the 1^{st} compressor 70 of 1^{st} rotor spool 42 and discharges **out the compressor exit** 53 of the compressor diffuser 34 and scroll 28 **and on** to the 2^{nd} rotor inlet compressor duct 150. The 1^{st} stage turbine nozzle 88 in close proximity to the 1^{st} stage turbine 71 with case insulation insert 36 to minimize radiant heat from the turbine to the compressor-diffuser 34, directs and accelerates hot gases 84 toward the bladed turbine rotor 71 to drive the integral compressor rotor 70. A thrust bearing 66 **is ID** attached to the rotor 42 **compressor shaft** and secured with nut/washer 72 and **OD bearing race one face is captured axially in the rotor spindle sleeve 54** [thru a common outer bearing race retainer] **and the other side is adjacent to the rotor retainer device** 74 [having] and **with a common** [ring retainer] **retention means** 76, **rotor spindle sleeve 54 with rotor retainer74** is axially positioned within the housing 20 and secured with nut 26. The housing 20 receives the 1^{st} spool module assembly 40 as a dynamically balanced system and has a relative fluid dynamic gap 30B, 30A between **sleeve 54 OD of** the **1^{st}** spool **module** 40 and **#1** housing 20 with supply oil 67 to bearing transfer having seals 52 in spindle **sleeve** 54 [yielding] **and with controlled oil film dynamic gap 30B, 30A** oil squeeze film dampers.

Oil drains away from bearings 66 and 58 via channels 30 and 105. Also, as

pictorial [pictoral] drawing of the present invention hybrid microturbine. Figures 3 and 4 are supportive, depicting ¼ cross-sectional assemblies of the 1st and 2nd spool modules and housings. The 1st spool [rotor spindle] **module** assembly 40 is dynamically balanced as a system and then located within the #1 housing 20 having relative case to spool assembly dynamic clearances with seals and oil squeeze film damping. The #1 **spool** housing module 20/40 is attached to the combustor housing 60 and secured with fasteners 22. The combustor 86A is incorporated in the housing 60 to develop fueled energy via fuel supply 164 and a turbine nozzle 88 directs the hot gases to the 1st spool turbine wheel 122B to drive the integrated spool compressor122A and alternator rotor 144. The heat shield 106 minimizes the radiant heat to the compressor-diffuser 158 within housing 140. A multi piece seal plate 124 controls cooling air flow to the 2nd rotor turbine hub 122B. The hot energy gas 84 exiting the turbine wheel 122B is ducted 82 to the #1 turbine nozzle 88 where it is then accelerated and directed to the 1st turbine blades 71 which in turns drives the 1st **rotor** spool [compressor] 42 with compressor blades 70 to yield pressure and air flow. The heat shield 36 minimizes the radiant heat to the compressor diffuser **34** adjacent to and within the housing 20. A multi-piece seal plate 48 separates the turbine **supply** hot gases [86B] **84** from the 1st **rotor** spool **42** compressor [122A] **71, diffuser 34** and regulates the cooling air flow to the turbine hub 122 and can be retained between the turbine nozzle and diffuser either by radial

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pins **like** 104 of figure 2 or simply sandwiched/pinched between the back of the diffuser [158] **34** of figure 2 and turbine nozzle 88. Air flow for this gas turbine engine enters/begins at the intake 24, then flows into the compressor wheel where blades [122A] **70** of spool 40 yielding high blade [70] exit velocity, and thru the diffuser 34 where a high static pressure is attained thru reduce velocity and then into and thru scroll 28 of housing 20. With pressure and volume the air exits **53** [the] **of** scroll 28 [at 32] then into the #2 compressor spool inlet duct 150. Oil supply and drainage are not shown for simplification. The structure material can be metal or non-metal, the scroll or the compressor exit area past the diffuser could be of various forms other than round cross section and or about a constant radial position. The housing could be cooled by means of a channeled fluid as an intercooler for reducing the air temperature thus increases the power density. Means to attach this housing 20 to the hot gas section can be other than a flange/bolt arrangement for example, a typical turbocharger clamp. This hybrid microturbine has higher power density over prior art.

The 1st [rotor] spool **module** [assembly] 40 [is a module and] is retained in the #1 housing **20, and** develops compressed air in this first stage from hot gas energy [33] **84** from the 2nd stage turbine 122B exiting side **to drive the 1st stage turbine rotor**. Figure 1 shows **interconnections of** the 1st [rotor] spool **housing module** [assembly] 40**A, 2nd spool housing module 140A** ,[and] **combustor 86A and combustor housing.** Figure 2 shows the related details **Figure 1**. Figure 3 depicts the 1st spool [assembly] **module** 40 positioned within the [case]

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[rotor] spool **module** [assembly] 40. Fig. 16 depicts the 1st rotor spool within housing 20 and relationship of the aft bearing 58 seal 56 rotor spindle sleeve 54 and o-ring seal 64, 52 with dynamic oil squeeze film dampers areas of controls [redial] radial clearances between the bearing 58 and spindle sleeve 54 and case 20 and spindle sleeve 54. Oil flow is channeled 57 to the bearing 58 and jet 75 directed to bearing 66 and #1 housing 20 houses spindle sleeve54. The 1st rotor spool [assemble] module compressed air the 2nd spool rotor compressor inlet 122. The **1st** rotor spool [assembly] 42 incorporates a compressor, turbine and **compressor** shaft which can be 1 cast unit, separate details bolted together or preferably an inertia welded structure typical to the automotive turbo chargers. The **1st** rotor **spool** 42 is a cantilever design having the bearing in a cool section to avoid a balance issue of a bowed rotor hot restart yielding rotor dynamic instability. This invention is not limited to the cantilevered rotor system of bearings one end of the rotor and could be straddle mounted with a bearing on each end of the rotor (oil is subjected to hot end contamination via excessive heat) and housed accordingly. A multi-piece seal detail 48 controls the air flow from the compressor to the turbine hot section, a means of cooling the turbine hub 122. Controlled radial clearances for rotor dynamic stability are incorporated between the spindle **sleeve** [housing] 54 and #1 housing 20.

Rotor **spool**42 thrust loads thru bearing 66 and **rotor** retainer **device** 74 to [case] **#1 housing** 20, the[ring] retention means 76 axially retains the rotor retainer **device** 74 and **thrust** bearing 66. Oil drainage is by gravity thru channels 30. The bearing 66 is

retained on the rotor 42 by a nut and washer 72. Reference figures 1,2,16 and 19**B** [defining] **defines** the aft bearing area of the #1 spool module 40.

Bearing 58 is positioned in the **#1 rotor** spindle sleeve 54 with a controlled radial gap oil squeeze film damper 63A and seals 64 could be replaced with a controlled axial face gap at either bearing 58 end such to control the leakage flow oil flow. In figure 19**B** the end seal 79 would restrict the oil flow with an axial face spring 78 and retainer 77 are incorporated along with an anti-rotation pin 73 is clearance fitted between the bearing 58 outer diameter and housing 54 having a common receiver and allow bearing limited motion for **1st** rotor **spool** 42 dynamic motion control. Oil is supplied thru cavity 67 and to the hydrodynamic bearing with thru flow about the **compressor** shaft [42] **70** discharging to drainage areas 30, 44, and 62. The labyrinth seal 56 is **start here** incorporated to keep the oil from the air flow path 24 and is pressurized with air from channel 46 air pressure from the #1 compressor aft cavity 70A. The labyrinth seal **56** and bearing 58 thru a common **#1 rotor spindle** sleeve [housing] 54 **retention** have similar radial motion with **compressor** shaft 42 thru the oil squeeze film damping area **30A** with the O-ring 52 area cavities and thus lessons the lab-seal 56 shaft area wear. Also the o-rings 52 in the front and aft bearing seal the oil flow in the **#1 rotor** spindle sleeve 54 could also act to prevent circumferential movement from the bearing/shaft resultant forces but as a safety measure an anti-rotation lug 79 or pin could be incorporated to interact with the [case]**#1 housing** 20.

The Combustor Housing 60 of figures 1, 2, 4 and 7 houses the combustor

86A, the #1 spool **housing** module 40A and the #2 spool **housing** module [a] 140A are retained. The hot gas energy 86B thru the nozzle 108 drives the #2 turbine **122B of #2** [rotor] spool **module** 120 and serially ducted 82 hot gases 84 pass thru nozzle 88 to drive the #1 turbine **71 of #1** spool 42.

The combustor 86A receives fuel **from injector 164** and is combusted within yielding energy-resultant hot gases **86B**. The #1 spool **housing** module 40A is attached to the aft end of the [scroll]**duct** 82 of housing 60 with integral turbine nozzle 88 and [is] sandwiched between **this nozzle and** the diffuser 34 is the multi-**piece** seal plate 48 and heat shield 36. The forward open end of housing 60, receives and mounts the #2 spool **housing** module 140A.

The housing 60 radially inboard area about the exhausting area 84 are located radial fins 87 aligned to the passing combustor dilution air flow such to remove case heat from the static seal land and adjacent assembled seals 102 and could support the combustor inner diameter, also this fin area could be used to regulate the dilution air flow to the exiting end of the combustor 86A. If the turbine nozzle were not [intergral] **integral** to the case 60 addition aft seals like 102 could be integrated along with radial pins like 104 reflective of the #2 nozzle retention depicted. The housing structure would see temperatures as high as 1350F and could be cast and or of sheet metal/ bar stock construction. The combustor case **60**

diffuser 158 and turbine nozzle 108. Seal 102 is installed into the nozzle 108 and prevents air 89 leakage into the [scroll 82] duct area [86] **82**. Hot gases exiting the nozzle 108 creates power thru the 122B turbine of rotor 122 and exits the turbine axially into the case 82 area of [scroll] **case** 60. The turbine rotor **71** extracts energy from the **hot energy** gas stream **84** and converts to rotational power. The

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and iron core laminats system 80. The 2nd rotor spool [assembly] module 120 can be viewed in figures 1,2,4,5,7,12 and 17. This spool accepts fueled energy expanding hot gases 86B thru the 2nd turbine nozzle 108 directing/accelerating onto the turbine blade 122B to drive the compressor 122A and alternator 144. The **compressor** shaft **122**, compressor **122A** and turbine**122B** are conventionally welded like turbocharger of the automotive field for reduced cost. A multi-piece seal 124 is positioned to regulate the compressor cooling air to the turbine disk/ blade122B area. The bearing**-seal** housing 126 in [module] **2nd** [rotor] **spool** [assembly] module 120 is integrated between the alternator rotor **144** and [alternator] **compressor rotor 122A** and has air and oil seals 130 of figure 5. The module 120 allows for final balance without rotor disassembly related case installation. The bearing**-seal** housing 126 with the preferred embodiment **is** depicted in figure 12 **and** retains the aft bearing 125, associated oil seals 147, anti-rotation pin 143, axial retention spring washer 145 and retainer146. A controlled radial gap 63A is incorporated between the bearing 125 and housing 126 to allow for an oil squeeze film damping system to control the rotor dynamics of rotor spool module

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120, shaft 122. As an alternative to figure 12 bearing arrangement, figure [19] **19A** could be implemented where the hydrodynamic bearing 125 with cylindrical gap [63] **63A** controlled oil squeeze film could be retained circumferentially by a pin [143] **73** axially positioned (or radially) with the seals

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126 and seal 79 sides, incorporating a bearing/seal retention ring [77] **146**, seal ring 79 and spring washer [78] **145**. An oil film damping system **in Fig. 19B** is also considered in the radial gap 63A between the **rotor** spindle **sleeve** [housing] 54 and bearing 58. An oil squeeze film damping system is also depicted in the cylindrical/radial gap between housing 126 and **#2** housing 140 with associated seals130. Oil is supplied to the bearing 125 thru channel 149 and radial squeeze

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via gravity means. An air labyrinth seal 132 and seal 0-rings 128 are mounted in **bearing-seal** housing 126 and retained axially via snap ring 148 with circumferential retained via the o-rings. The lab seal 132 limits compressor air duct 168 leakage into the **bearing-seal** housing 126. The radial holes 129A of seal 132 in figure 12 allow for air leakage to go overboard housing 126 connected and housing 140 channel 131

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connect to allow overboard flow. In figure 5 both the lab seal 132 and bearing 125 with [retain] **retainer** 138 could be hard mounted to the housing 126 allowing oil squeeze film damper only between support 126 and 140 housing offering further simplicity. Axial thrust load from 168 compressor pressure would require a means to limit resistance at face flange 133.

The 2nd spool rotor bearing support assembly 160 of figure 18 retains the thrust bearing 186, positions the rotor **shaft** 122 **of the #2 spool module 120** and incorporates oil squeeze damping between the bearing 186 outer race and

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the rotor 122 of [module] **the #2 spool module** 120 with nut 188. The alternator rotor 144 shoulders to the bearing inner race 186A. The bearing support assembly 160 is retained to the 2nd housing 140 using bolts 184. The bearing 186 and **#2** [rotor] **spool** module 120 are axially positioned thru shims 198. The [2nd]**#2 spool** housing module 140A of figure 2 includes: an alternator stator module 80 for electrical power output [has] **having** a cooling sleeve 94, stator wires 97, iron laminats 92, stator retention screws 99, and power output lugs 212 fig. 13 within a lug / insulation assembly block 180, **insulation block detail 202**, an air start housing cavity 156 of figure 4 with an air supply port 154 of figure 7 and to

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inlet duct section 150 accepts compressed air 53 from the 1^{st} spool module exit port 32 of figure 1 and delivers air **53** to the 2^{nd} compressor122A and inlet 168 where air is further compressed and passes thru the diffuser 158 and onto the combustor 86A within [housing] **combustor case** 60. Fuel is delivered thru an injector port 164 to the combustor fig.1. There are associated controlled radial clearance between the spool rotor support 126 and the [2^{nd} case] **#2** housing140 with seals 130 and bearing 125 of figure 12, 2 and 4 for rotor dynamic consideration. Pressurized air flow enters this

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122A or a reduced diffused flow velocity radially in from one side of the inlet 168 with vane position 152B. Also during reduced power/flow and with the engine 2^{nd} **rotor** spool **122** requirement of maximum RPM the plate can be positioned 152A to restrict the air flow. Other means of induced rotor 122 inlet preswirl

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incorporate a pressurize CO2 means for a fluid tangent force to [case] **induce** [starter] **#2** spool [reotation,m] **rotation** or channeled tangent pressurized fluid to the turbine wheel 122B. The J-5-1 turbojet in 1969 used an air start system which directed air to the turbine wheel and later in 1972 Williams incorporated similar approach but used an explosive gas onto the turbine wheel for the cruise missile engine application removing their need for gear box starter. The alternator

stator module 80 of figure 1, 2, 4, 18 and 13 has magnet wires 97 and iron core laminats 92 to provide electrical energy output from the relative rotational motion between the alternator 144 of the 2nd rotor **spool** [module] 120 and electrical stator module 80. A heat exchanger **94** using oil media is

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electrical phase requirement the lead/ wire lug quantity [216] **212** and stator wire 97 could be 1, 3, 6 or more. Terminal lug 212 is mechanically 208 screwed and soldered to the stator lead **wire** 97 and with any quantity of terminals [21] depending on the stator phase requirement. The [luq] **lug** 212 has o-ring seal 208 at one end and retained within the terminal block 202. Round holes in the block

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The 1st spool housing module 40A of reference figures 1, 2, 3, 6, and 16 is the turbo charging stage of the invented hybrid microturbine. The 1st spool [rotor] module 40 a rotative device initiates the inlet air flow from atmosphere. The resultant increased air pressure of this first stage is delivered to the 2nd spool inlet 168 via the exit port 32**, flow 53** and transition duct 150 of [case]housing 140. The 2nd spool [rotor] compressor 122A exits air flow 89 communicates with the combustor 86A and combustor housing 60 and within [th] **the injected** combustor fuel **from injector 164** is mixed with air and ignited to create a continuous flame of

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122A and the [coupled] **integrated** alternator rotor 144 of **2^{nd} spool** module 120. The relative rotation between the alternator rotor 144 and stator module 80 creates output electrical energy/power and exits thru the terminal block module 180 for external connection – usage. The hot gases 84 from the 2^{nd} turbine wheel 122B exit area are ducted 82/60 to the 1^{st} turbine bladed rotor 71 of **1^{st} rotor** spool 42, **1^{st}**

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spool module 40 thru the use of the turbine nozzle 88 of combustor housing 60 for a [direct]**directed** velocity (this could be separate).

A one piece cast housing could incorporate the 1^{st} spool housing 20 and 2^{nd} housing 140 and yielding generally **1^{st} rotor spool** parallel to the 2^{nd} rotor spool. Also, air impingement starting could be incorporated similarly of the 2^{nd} spool start scheme into the 1^{st} spool **housing** module 40A as a separate engine start

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[and] **an** integral air impingement system/black start capability using stored engine air pressure or auxiliary means; applying the air pressure tangent to the #2 rotor spool compressor wheel exit area to cause rotation/initiate air flow with associated bearing oil flow and fuel flow delivery to the combustor/injector at approximately 10% of maximum operational rotor speed; simultaneously the air flow traveling to the 2^{nd} rotor spool thru the common ducting of the 2^{nd} housing and 1^{st} housing the air flow kinetics will cause the 1^{st} [rotor spool] to rotate within

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the 1^{st} spool housing **module**. Once the combustor is developing chemical fuel energy the 1^{st} spool thru the connected 1^{st} turbine and being exposed to this expanding gas energy will further cause acceleration to this 1^{st} rotor **spool as a** turbo charging stage. The main engine air intake is at the entrance of the 1^{st} spool housing and [and] the

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reduce with lower power needs and the maximum power will be limited by the turbine inlet temperature (TIT) of the #2 rotor **spool** thru a control monitor of the turbine exhaust gas. During normal engine operation air flow from the 1^{st} rotor spool

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directs the hot gases with increased velocity toward the blade turbine wheel creating power to drive the 2^{nd} [rotor] spool compressor and alternator rotor. The alternator rotor relative rotation to the alternator stator module causes electrical power energy and output in thru the power terminal. The hot gases leaving the 2^{nd} spool rotor turbine exits into the combustor housing scroll section where the reduced temperature hot gases are directed to the #1 rotor spool blade turbine wheel to cause rotation and the power extraction drives the 1^{st}compressor bladed wheel. The hot gases with further reduced temperature thru the turbine wheel energy/power extraction exits the turbine wheel and combustor housing. The #1 spool **rotational** speed will vary based on power demand for the #2 spool, an aero thermodynamic product.

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